AGENDA

AEROSPACE SAFETY ADVISORY PANEL MEETING

JULY 12-13, 1971

JULY 12

Review of Status of Apollo 15 - Dr. Rocco Petrone, Apollo Program Director.

Panel Discussion of Apollo 15 Report

Dr. Low's Office - Presentation of NASA Public Service Award to Dr. Reining

Benefits vs Risk Management for NASA - Dr. Raymond Wilmotte, NASA Consultant

JULY 13

Dr. James C. Fletcher, NASA Administrator

Appendix G

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

REPLY TO
ATTN OF:

OFFICE OF THE ADMINISTRATOR

September 30, 1971

MEMORANDUM

TO: OSP/Executive Secretary
Aerospace Safety Advisory Panel

FROM: AD/Deputy Administrator

SUBJECT: Aerospace Safety Advisory Panel Activities

Thank you for your memorandum dated September 28, 1971, on the same subject. I very much appreciate your summarizing for me the Panel's recent activities.

The agenda for the Panel's visit to Huntington Beach appears to be sound and well thought out.

I recently received a copy of the final report to the Lewis Research Center of the Centaur Quality and Workmanship Review Board, dated August 1971. You might want to make copies of this report available to Panel members, not for the purpose of reviewing the Centaur Program, but for additional background in their review of the Apollo and Skylab programs.

George M. Low
George M. Low

Attachment C

NASA

AEROSPACE SAFETY ADVISORY PANEL

SPECIAL OWS INTEREST ITEM NO. 1

The Panel was quite concerned with the quantity of flammable material which is incorporated in the OWS. We appreciated the reasons given for the necessity of using this material. Since possible fire aboard the vehicle must be considered we would appreicate receiving a fuller description of the on-board equipment and crew procedures which will be used to detect, contain, and extinguish fires if one should start. In this regard we would also like information on studies of the possible effects of toxic materials which might be generated during a fire, damage control, and the establishment of limits of contamination as applied to atmosphere composition.

Attachment D

OWS Flammability Control

The safety provisions of manned spacecraft must always consider the question of a potential fire. All aspects of such a hazard must be evaluated in order to minimize possible ignition and effect. This includes probability of ignition, flame propagation paths, containment if a fire occurs, and toxicity effects on the crew from combustion products.

Since the beginning of the design phase, it has been NASA/MSFC's and MDAC's philosophy that the key to crew safety is fire prevention. MDAC has implemented this policy by communicating to the designer that special design precautions are mandatory when using known flammable materials. This emphasis on the design techniques for fire prevention has promoted a concept for fire containment and the elimination of flame propagation paths, if a fire did occur. The use of any flammable material is contingent upon isolation of such material or materials in the composite configuration. Flame-containment design techniques include isolating each flammable material from other materials by enclosement, by encapsulation, or by use of a barrier between the material and the operating atmosphere. Each of the design applications has been reviewed by MDAC and NASA/MSFC to determine adequacy of the precaution to insure that safety provisions are satisfied.

The following discussion presents a general overview relative to fire detection, containment, and extinguishment provisions, and toxicity control within the OWS. It should again be emphasized that the basic ground rule applied to the OWS design is fire prevention. Use of all flammable material is reviewed and documented as follows:

(a) All flammable materials are identified and reported on Materials Usage Forms. These forms include area, volume, weight, and location information for each flammable material usage. In addition, this form also includes offgassing data (carbon monoxide and total organic offgassing rates) for each material.

(b) All forms are approved by the OWS Program Manager and are submitted to MSFC for review and approval.

OWS Flammability Control (Continued)

(c) Flammable material is used only when no adequate non-flammable substitute is available. Detailed rationale and tradeoffs are included with each material submittal.

(d) Each submittal item is also included as a part of the Materials Usage Map (MDAC drawing No. 1B77015). This drawing depicts the location of each item and aids in determining the distribution of material throughout the OWS and its proximity to other items.

Fire Detection

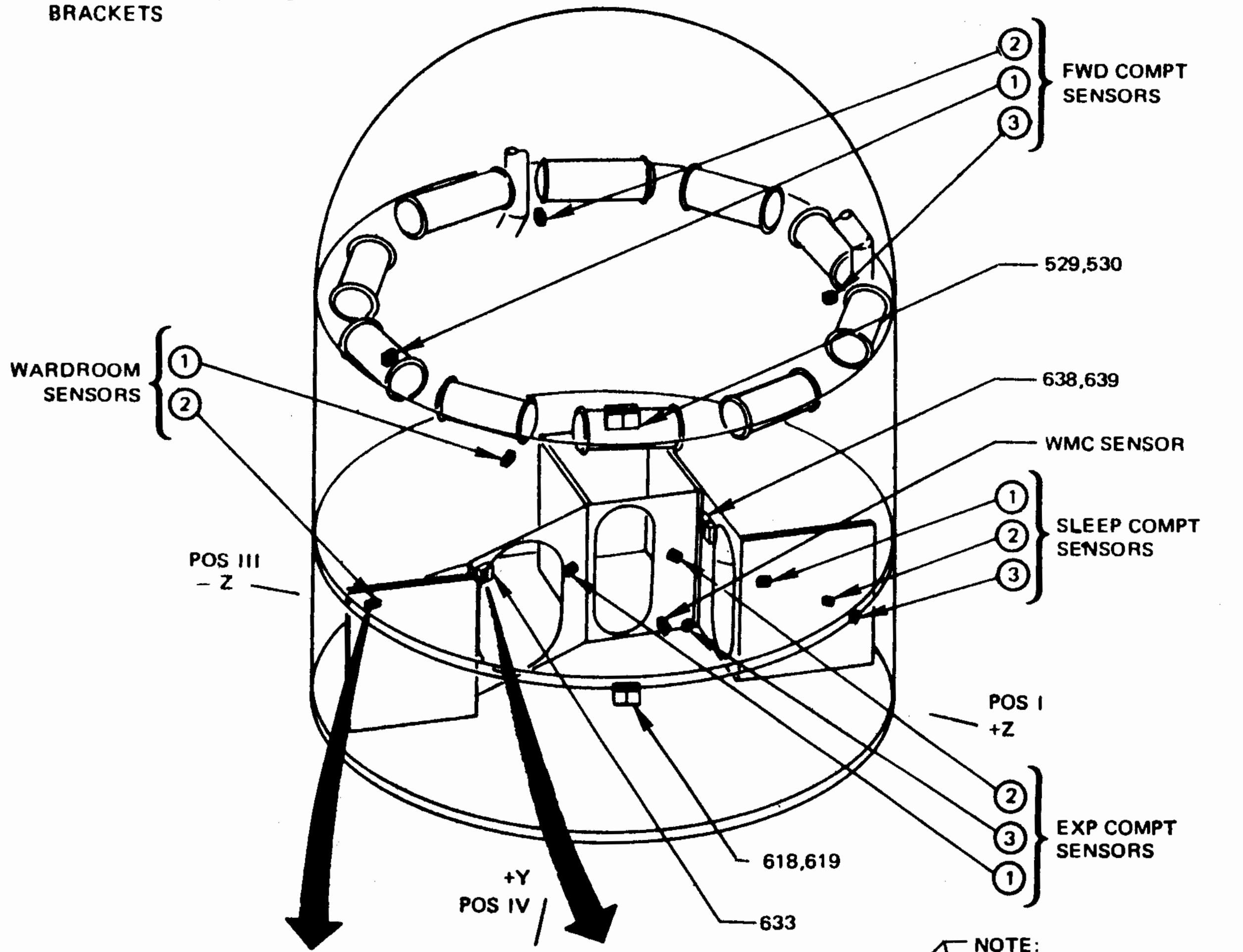
A fire detection system study was conducted and the results reported in MDC G0095-P, dated 8-20-70. The results of the study indicated that an adequate fire detection system could be achieved by incorporation of an area-type surveillance technique using single coverage ultraviolet detectors.

The OWS fire detection system is comprised of 12 ultraviolet sensors and seven associated control panels. The basic placement and arrangement of sensors and control panels is depicted in Figure 1. Exact locations of the fire detection sensors are defined by drawing No. 1B86999 (January 1971) for all sensors except the Waste Management Compartment sensor which is defined by drawing No. 1B79489 (January 1971).

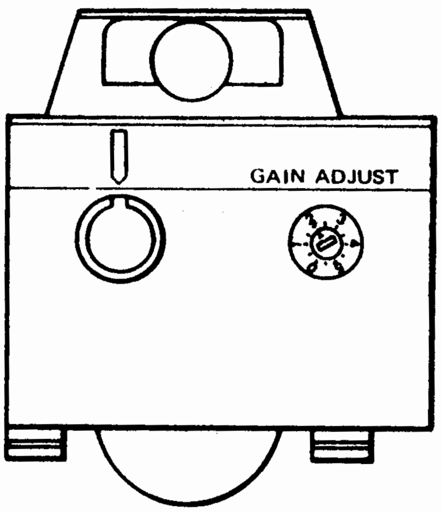
The above locations have been used to determine the approximate area covered by the field of view for each sensor. The sensor field of view is a 120 degree cone and the installation alignment angles are: (a) aft compartment sensors cone centerlines are canted 30 degrees upward from the horizontal for floor mounted sensors and 30 degrees downward from the horizontal for ceiling mounted sensors, (b) forward compartment sensors cone centerlines are horizontal.

The projection of the conical field of view of each sensor on the floor and ceiling of its respective compartment has been established and straight line approximations developed for the intersections with the surrounding walls. This effectively defines the area which would be within the field of view for each sensor. Adjustments in the placement of the sensors were made based on the coverage definitions to provide the most effective viewing position for each sensor.

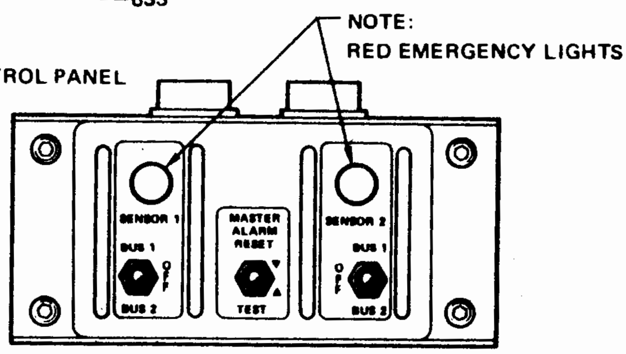
NOTE: PANEL NUMBERS AND SENSOR NUMBERS APPEAR ON MOUNTING BRACKETS



SENSOR (TOP VIEW)



CONTROL PANEL



PANEL	FIRE DETECTION SENSORS
529 (LEFT)	FWD COMPT 1, 2
530 (RIGHT)	FWD COMPT 3
618 (LEFT)	EXP COMPT 2, 3
619 (RIGHT)	EXP COMPT 1
633	WARDROOM 1, 2
638 (LEFT)	WMC AND SLEEP COMPT 1
639 (RIGHT)	SLEEP COMPT 2, 3

Fire Detection System – Panels 529, 530, 618, 619, 633, 638, 639 (61A300026 GFE)

Fig I

Fire Containment

Protection provisions for containment of fires are as follows:

(a) Installation of fixed items. The majority of the fixed (permanently installed) flammable materials are small in size, separate items, or easily isolated component parts. Exceptions include the foam insulation, refrigerant, and wire harnesses. The general design approach followed is to contain and/or isolate the flammable material. Enclosure with metal (provides a large heat sink), wire troughs with fire breaks, or isolation by separation from other flammable materials are the commonly used approaches. Each usage and its installation and protection/isolation provisions are documented and submitted on a Materials Usage Form as discussed previously.

Fire Containment (Continued)

Special precautions and design provisions have been imposed and Incorporated with respect to the major usages of fixed flammable materials. These include the following:

(1) Polyurethane foam insulation installations are covered by a minimum of .003 inch thick aluminum foil. The tank wall insulation also includes use of a fiberglass liner which in turn is covered by the aluminum foil. All penetrations through the foam incorporate use of fiberglass and aluminum foil protective covers to isolate the foam from exposure to the OWS atmosphere. Polyurethane foam used within freezer walls is essentially sandwiched between metal walls of .030 minimum thickness. Extensive flammability testing was conducted to determine the minimum foil thickness which would provide the desired flammability protection.

(2) The refrigeration subsystem installation incorporates the following design provisions to eliminate potential leak paths for the refrigerant:

(a) all tubing joints within the OWS pressurized interior are brazed

(b) "O" ring sealed boss fittings replace use of MS flared fittings. This provides the interface seal between the CRES tubing and aluminum active components

(c) all active components are enclosed in a sealed, vacuum vented container.

(d) damage protection is provided by the use of foam insulation jackets around the refrigerant lines (thermal requirement) which in turn are covered by .050 inch minimum wall thickness aluminum shrouds.

In addition, extensive flammability testing was conducted using typical segments of refrigerant soaked insulated lines to substantiate the adequacy of the design approach.

Fire Containment (Continued)

(3) Electrical components and wiring installations incorporate the following special system design features, in addition to normal circuit protection devices:

(a) all encapsulated electronic modules are coated with a layer of plasma-arc sprayed aluminum (Metco No. 54) to preclude flame propagation.

(b) all wiring internal to the OWS is routed through a system of closed metal troughs containing fire barriers or non-flammable convoluted tubing

(c) the power control console is compartmented to prevent flame propagation.

(b) Stowed items. Flammability protection for stowed items is provided by the metal stowage cabinets. Installation of stowed items does not include any specific requirements to fire proof the item prior to placement in the cabinet. The stowage interface is concerned only with size, weight, vibration, shock, and flotation (zero-g) constraints.

Stowage restraints and/or packaging provided is non-flammable, where possible, (armalon bags for small items or non-flammable strap type restraints for larger installations).

Specific stowage concepts applied to significant usage of flammable materials (large mass) are:

ITEM	CONCEPT
Sleep restraints	Restrained in cabinet by straps except for the three in use which are protected by an armalon stowage bag when not occupied by a crew member.

Fire Containment (Continued)

ITEM	CONCEPT
Towels	Rolled individually and stored in bundles. Usage is from a dispenser which is comprised of 24 towels in a metal container closed on five sides. The dispenser is installed within a metal cabinet. Only the rolled end of the towel cylinder is exposed to the atmosphere within the cabinet. Bulk stowage of replacement towels for the dispensers is within a cabinet restrained by straps.
Washcloths	Stowed in bundles of 28 cloths in a metal container closed on five sides. This container is installed within a metal cabinet. Cloths are extracted through an oval hole in the sixth side of the metal container.
Tissue/Wipes	Stowed in closed aluminized box. Used in a tissue/wipe dispenser at which time the ends of the box are punched out. The dispenser installation uses a spring loaded door which must be opened to remove a tissue/wipe. The dispensers are installed within a metal cabinet.
Bags (Trash, Urine, etc.)	Stowed in bundles, within metal cabinets and strap restrained. Exposure is limited to the usage duration only.

(c) Ignition Sources. All electrical equipment connecting to the power distribution system have been reviewed as potential ignition sources. This review assumed that the circuit breakers failed closed, all environmental seals leaked, and one or more components failed. Results of this review are that the wire gauge used in the circuit breakers and electrical components is less than that of the interconnecting wiring and acts as a fuse to open the circuit should failures occur.

Fire Containment (Continued)

In addition, the wiring installations use the enclosed trough and convoluated tubing approach which effectively enclosed all the wiring and isolates any malfunction from the remainder of the system.

The OWS main bus wiring internal to the control-display console was evaluated in greater depth since failures here can cause total loss of power and possibly cascading malfunctions. It was concluded that additional protection was warranted although only extremely peculiar short circuit conditions would cause burning of wire insulation. Typically this would be a short which would draw just enough current to cause the temperature to rise but not enough to trip the breaker (virtually impossible). Should this occur shorting of an adjacent wire would trip the breakers and open the circuit. No cascading failures are considered possible.

These wires have been designed with a completely redundant double insulation jacket to preclude possible short circuit failures as discussed above.

A review of potential hot spots (temperature >+160°F) was conducted as part of the possible coolanol hazards assessment. The results of this review have identified the following potentially sensitive areas.

Radiant heaters - for bus voltages not greater than 28 vdc, the temperature of the heater surface cannot exceed +160°F. Estimated maximum temperature with maximum bus voltage (32 vdc) exceeds +160°F (coolanol flash point). However, no astronaut safety hazard exists because these heaters are not active while the OWS is inhabited and no heater failure can occur at the temperature seen at maximum voltage.

Duct heaters - failure of all the fans (minimum of three failures) within a duct would allow the heater temperature to reach +260°F (maximum overtemperature). Operation of a single fan would limit the temperature to +150°F.

Fire Containment (Continued)

Static electricity discharge potential for all the OWS equipment is controlled by bonding requirements defined by OWS Design Memorandum No. 28 to assure compliance with Electrical Bonding specification MIL-B-5087B. Specific design requirements and maximum allowable DC resistance data for application to experiments, structural interfaces, conductive adhesives, portable equipment, and electrical AGE are included in this memorandum.

Conclusions reached relative to ignition sources are as follows:

- No electrical power distribution system ignition sources exist.
- Potentially sensitive hot spots (temperature +160°F) exist with the radiant heaters if the bus voltage is above 28 vdc and the duct heaters if four failures occur.
- Static electricity discharge potential has been eliminated from MDAC-supplied items.
- No flammables are located in proximity to any of the above possible sources.
- Radiant heaters and duct heaters are monitored by the fire detection sensors.

Fire Extinguishment

The OWS CEI Specification, CP2080J1C, establishes the requirement for mounting four fire extinguishers in the OWS. Two extinguishers are to be mounted in the crew quarters and two in the forward compartment. The extinguishers are to be furnished by the Government according to OWS GFP contract document DAC-56724A.

Specific fire extinguishers usage procedures as well as overall emergency operational procedures are the responsibility of Mission-Control NASA-MSC. MDAC is responsible only for the determination of the quantity of extinguishers required in the OWS to satisfy the primary mission safety requirements and to provide mounting provisions for these extinguishers.

Fire Extinguishment (Continued)

The fire extinguishers have been modified to incorporate a low velocity nozzle so that they may be used effectively against open fires. The previous design used a nozzle which fit into holes in the cabinet panels within the Apollo command module. The command module cabinet would then contain the expended foam. No such holes or panels exist in the OWS design. The approach used is to enclose OWS wiring, components, and stowed items within metal compartments and testing has been conducted to insure that this approach satisfies all fire containment requirements.

Toxicity Control

A computer program, P0327, has been created to provide a mechanism to collate and calculate offgassing rates for the non-metallic materials used in the OWS. The concern is with the potential buildup of toxic products above allowable limits for the materials used in the normal operating environment. The computer program calculations of total offgassing of carbon monoxide and total organics provides OWS Crew Systems personnel with data to assist in establishing the level of toxic contaminations. No program or data exist relative to toxic levels resulting from products of combustion. A fire, other than a minor localized one, in the Orbital Workshop causes an emergency situation which may be met at that moment by providing oxygen and masks located in the crew quarters.

NASA

AEROSPACE SAFETY ADVISORY PANEL

SPECIAL OWS INTEREST ITEM NO. 2

"In view of the Russian accident involving the loss of three cosmonauts which presumably resulted from inadequate containment of the atmosphere in the space capsule, we are naturally interested in any studies that you have done pertaining to the adequacies of closure of all hatches and other penetrations of the OWS shell which could potentially result in catastrophic loss of atmosphere. I believe that Houston has made an overall survey of this potential but we are particularly interested in the studies that MDAC may have made for those parts of the equipment for which they are responsible."

OWS Atmosphere Integrity

The OWS does not include the type of equipment (primary entry hatches) which was assumed to be the malfunctioning item which caused the Russian Astronauts' death. There are also other basic reasons why the OWS is a safe element of the Skylab in this respect. These reasons have different value with respect to a problem or accident occurrence and are listed for evaluation in any context under discussion.

1. The OWS volume is approximately 9,500 cubic feet. At 5 psia the mass of breathing atmosphere (oxygen and nitrogen) contained is 295 pounds. A catastrophic loss of atmosphere would require a much larger hole than would be related to a seal type leakage. Also, pressure is monitored and make-up gas is available.

2. The OWS does not have any EVA hatches or other large openings which are functional in orbit. The entry hatch at the forward end of the OWS is opened by the astronauts during initial activation and remains open into the AM for the duration of the mission.

3. The OWS is pressurized to 23-26 psia for launch. When the vehicle reaches orbit it has experienced full differential pressure prior to initial blowdown. The OWS is then repressurized to 5 psia with the breathing atmosphere. During these period of time the OWS pressures are monitored from the ground. This provides a gross evaluation of the structural and leakage integrity of the vehicle prior to crew launch.

4. The only OWS Habitation Area shell penetrations having relatively large openings are the trash airlock, which opens into the Waste Tank, and two scientific airlocks which penetrate the sidewalls of the forward compartment. Both of these items incorporate interlocks which prevent simultaneous operation of inner and outer doors.

5. The Habitation Area vent systems are closed with redundant sealing devices during periods of occupancy. These sealing devices are installed by the astronauts and venting is impossible with the seals in place.

OWS Atmosphere Integrity (Continued)

MDAC, Huntington Beach, has not made any special studies in relation to catastrophic loss of atmosphere. However, internal design reviews and formal design reviews with NASA/MSFC have been conducted on each system in the OWS which includes all shell penetrations. Reliability analyses have been conducted and contingency analyses forms documented for each OWS functional component incorporating an overboard leakage path. Static seals are individually checked to a degree of sensitivity compatible with the eight month's orbital stay time. Each overboard leakage point is tested during manufacturing, checked during vehicle systems checkout at Huntington Beach, and checked again at KSC prior to launch. In addition, MDAC will conduct a OWS Habitation Area Gross Leakage Rate (Mass Decay) Test. This will provide additional assurance that leakage integrity is obtained.

NASA

AEROSPACE SAFETY ADVISORY PANEL

SPECIAL OWS INTEREST ITEM NO. 3

The Panel was very impressed with the detailed attention and interest given to the acceptability of parts and components which are supplied by subcontractors or vendors. In order to more fully understand how this management system works we would like to have you describe it to us in terms of an example selected from a component critical for either safety or mission accomplishment. As a method of providing for us an understanding of the system we would suggest that you include (a) an outline of the basic process for receiving, inspection and acceptance testing of the component, (b) any changes introduced in this process during the last six months, and (c) a tabulation of the nature of any failures to meet acceptability of this component and the resolution of the problems resulting therefrom. The purpose of this example should be to give the Panel a management assessment indicative of the effectiveness of this system for control.

OWS Supplier Parts Management

The part selected to describe how the supplier parts management system operates is P/N 1B75338-503, Thermostatic Switch, which is produced by Elmwood Sensors, Inc. located at Cranston, Rhode Island. Elmwood Thermostatic Switches are utilized in the data acquisition system, the environmental control system and on the microbiological control unit. In the environmental control system and on the microbiological control unit, the thermostats are used as a back-up method of temperature control in the event the primary system fails. In the data acquisition system, the thermostat is the primary control for the multiplexer heater blanket. The multiplexer thermostat is considered Mission Safety Critical because if the thermostat fails to open or close, the multiplexer will be subjected to temperature extremes in excess of its qualified operational temperature. Loss of a multiplexer would result in the loss of vital telemetry data such as biomedical information on the health of the astronauts.

The Elmwood Thermostatic Switch was selected because of problems encountered with this item in our Receiving Inspection and Test Laboratories. The nature of the discrepancies caused the parts to be rejected and returned to Elmwood for redesign. The following outline of activities related to planning, receiving, inspection and testing of the Elmwood Switches, cross referenced to the applicable documentation, should serve to clarify the various facets of our Supplier Management system.

Planned MDAC Acceptance Activities and Implementing Documentation

1. Initiate Quality Management Plan as guide for preparation of the Quality Assurance portion of the Procurement Work Statement (Encl. 1).

2. Prepare Material Acceptance Plan which is the prime document to plan, route, inspect, test and record results for acceptability of supplier part (Encl. 2).

3. Impose MDAC Reliability Control Specification, RCS400-2 and Government Source Inspection (GSI) on supplier. (See Purchase Order, Encl. 3).

Planned MDAC Acceptance Activities and Implementing Documentation (Continued)

4. Verify supplier compliance with RCS400-2 by on-site audit. (See Survey Report, Encl. 4).

5. Conduct Supplier Hardware Assurance Review Program (SHARP) Survey to assure supplier understands engineering intent. (See SHARP Survey Report, Encl. 5).

6. Qualify supplier special processes; i.e., cleaning, soldering, welding, clean room, etc. See Records of Discussion, Encl. 6 and 7.

Receiving Inspection, Test Activity and Implementing Documentation

1. Perform Receiving First Unit Review. (See Encl. 8).

2. Verify MDAC approval of the following:
   a. Supplier's Product Inspection Plan (See SIR84112, Encl. 9).
   b. Supplier's Test Procedure (See SIR84112, Encl. 9).
   c. Supplier's hardware design (See page 3 of SIR84112, Encl. 9 and SIR85131, Encl. 9A.)

3. Verify Government Source Inspection was performed. (See Section A of MAP and QA Stamp buyout on first line of Section D. The QA Stamp buyout verifies all requirements marked "X" in Sections A, B and C were satisfactorily performed. Encl. 2).

4. Verify receipt of supplier's Certificate of Conformance for process requiring qualification by MDAC. (Encl. 2 and 10).

5. Review supplier test data for conformance to MDAC requirements. (See Acceptance Test Data Sheet SR021 and MAP, Encl. 11 and 2).

6. Perform visual/mechanical inspections to requirements of MDAC Spec Control Drawing 1B75338. Part rejected on FARR 502 020 298 because of improper potting. (Encl. 12).

7. Perform MDAC Acceptance Test (Electrical/Performance Parameters) per MDAC Product Acceptance Test Procedure (PATP). (See PATP and FARR 502 027 376, Encl. 13 and 14).

Receiving Inspection, Test Activity and Implementing Documentation (Continued)

8. Verify performance of Seal Leak Test by outside laboratory (Isovac Engineering). (See Isovac Test Certification results and FARR 502 028 596, Encl. 15 and 16).

   NOTE: No changes to the above basic supplier management process have been introduced in the last six months, however, several remedial actions were taken as listed below.

Product Acceptability

1. The initial planned acceptance activities progressed satisfactorily up to the point of Receiving Inspection and Test. The following is a summary of product discrepancies discovered during inspection and test:

   a. Bondizing ineffective
   b. Encapsulation defective
   c. Insulation resistance low
   d. Switch points out-of-tolerance
   e. Leakage rate excessive

2. Subsequent to the initiation of the rejection reports, a Supplemental Failure Analysis was initiated and an extensive evaluation of the problems was performed by MDAC Engineering both in-house and at the supplier's facility. (See SFA #W019, Action Item Summary Sheet and MM&RE report, Encl. 17, 18 and 19.)

3. Following these evaluations, all -503 configured parts were withdrawn from MDAC usage and a redesign -511 was initiated. Included in this redesign is both new controlling criteria in the Specification Control Drawing and a revision of the supplier's engineering, manufacturing and inspection procedures. (See Stop Order Encl. 20.)

4. Present status of the Thermostatic Switch is Interim Use Parts are being used for Phase I (Power Off) of checkout, "L" change to the drawing has been released calling for use of the -511 configuration and the supplier's revised drawings have been reviewed and approved by MDAC Engineering. Elmwood Sensors has been given a production go-ahead and new parts are scheduled for delivery on or about 3 December. (See SIR87439, Encl. 21. and L Change EO, Encl. 22).

NASA

AEROSPACE SAFETY ADVISORY PANEL

SPECIAL OWS INTEREST ITEM NO. 4

Since check-out testing of the OWS is planned to commence on November 6 the Panel would like to have you identify those items of flight hardware that are not expected to be available and/or installed on the workshop at that time. We would like to have your management system for the followup of such "shortages", particularly in regard to such assurance that the proper check-out test program will be applied as these items become available at subsequent dates.

OWS Hardware Status for Checkout

The spacecraft hardware status is controlled and monitored in terms of remaining open work. OWS hardware status was reviewed on 4 November 1971 for NASA and MDAC management as part of the Readiness Review for start of Phase I (Power Off) Checkout. The prediction for start of checkout was forecast to be 6,390 hours of remaining open work (Chart 1), however, on 6 November, checkout started with 6,109 actual hours open. The open work has been divided into four categories (Chart 1) with typical examples in each category (Charts 2-5). This open work has been scheduled into established modification periods during checkout such that is supports and is compatible with the various phases of tests. (Chart 6).

For the start of checkout, custody of OWS-1 was transferred from Manufacturing Operations to the Vehicle Checkout Laboratory (VCL). To complete this transaction, the appropriate "turnover" documentation was prepared and included a copy of the daily Automated Work Plan (AWP) which contains a complete breakdown and listing of open jobs and part numbers. Turnover AWP is enclosed. (Cht. 7)

OWS Hardware Management

The management system to track and follow-up on OWS parts is centralized into twice daily meetings with the company president, program manager, director and supervisors. The meetings are conducted in the tower building next to the spacecraft where magnetic boards are located which post the real time status of all open jobs on the spacecraft. Discussions are made and directions issued at these meetings to improve part availability dates and properly schedule the installation effort consistent with the test phases. The status as posted on the magnetic boards is photographed and disseminated to the involved agencies daily. A copy of the 11 November 1971 magnetic board status is also enclosed. (Encl. 8)

"Shortage" Management During Checkout

To assure that shortages are not overlooked during checkout, the VCL maintains practice of redlining a Test and Checkout Procedure (TCP) when it is necessary to work around a part shortage. This type of revision, however, is used as an internal technique only. The test procedure itself remains open until the proper component is installed and that portion of the procedure that has been redlined is then conducted in accordance with the original requirement.

In cases where components are changed after checkout, the Company uses a technique whereby any such change must have retest requirements specified on the installation paper. These retest requirements then become part of the data package and remain with the spacecraft until the rework has been accomplished and the installation paper can be sold off.

NASA

AEROSPACE SAFETY ADVISORY PANEL

SPECIAL OWS INTEREST ITEM NO. 5

As qualification tests have been conducted on the habitability support and electrical power systems, significant discrepancies have presumably been identified and classified according to cause as design problems, workmanship problems, or test procedure difficulties. We would appreciate receiving a historical review of your experience in this area.

OWS Qualification Test Review

In reply to the request for a historical review of the significant discrepancies identified in the habitability support and electrical power systems during qualification testing, the attached items with noted malfunctions constitute a synopsis of the major problems to date.

FAILURES RELATED TO DESIGN PROBLEMS

	LINE ITEM	TITLE	PROBLEM	CORRECTION/STATUS
1.	DA-3	Forward Signal Conditioning Panel	High temperature failure in 5-volt excitation module.	Seventeen components (resistors, capacitors, and transistors) were changed to those of different values. Item retested satisfactorily. Unit now in vibration and shock
2.	EC-11	Thermal Control Assembly	EMI failure of Driver Module.	Inductor filter added to circuit. Unit retested satisfactorily. Line Item closed.
3.	ES-3,-4	Zero G Connector, Phase II Zero G Connector	Manual operating force failure. Also, alignment pin failure during vibration.	Dri-lube added to mechanical lever mechanism. Longer pin inserted with different bonding cement. Item retested satisfactorily. Unit now in temperature life cycle.
4.	HS-8	Water Storage Assembly	Heater Blanket failed insulation resistance.	Connector potting compound and blanket material changed. Retested satisfactorily. Item active in biocide test.
5.	HS-10	Food Reconstitution Water Dispenser Assembly	Leakage problems in life cycles.	Gaskets and "O" rings changed to different configuration and material. Retested satisfactorily. Line Item closed.
6.	HS-11	Drinking Water Dispenser	Leakage problems in life cycles.	Gaskets and "O" rings changed to different configuration and material. Retested satisfactorily. Line Item closed.
7.	HS-12	Water Heater	Vibration failure of mounts.	Redesigned method of attachment and increased strength of mounts. Retested satisfactorily. Line Item closed.

	LINE ITEM	TITLE	PROBLEM	CORRECTION/STATUS
8.	HS-14	Microbiological Equipment	Biocide failure Iodine Injector (redesign). Vibration failure Waste Container (redesigned).	Bellows guide rings added to Waste Container and material in bellows of Iodine Injector changed to hastiloy "C". Both in fabrication for re-test.
9.	HS-24	Trash Disposal Airlock	Outboard hatch lever failed (seized) life cycles (redesigned). Pressure gage failed vibration.	Hatch lever mechanism redesigned to operate differently plus dri-lube being added to moving parts. Pressure gage redesigned by vendor. Both items in fabrication for retest.
10.	HS-27	Fecal Collector Blower (Apollo Evaluation)	Vibration failure of mounts. Mount structural beafed-up.	Structural strength of mounts increased plus new mounting technique incorporated. Item retested satisfactorily. Line Item closed.
11.	HS-48	Wash Cloth Squeezer	Mechanical linkage and bag leakage problems.	Mechanical linkage re-designed to increase structural strength and method of operation. Bag material changed. Both in fabrication for retest.
12.	CA-16	Spare Equipment Stowage Container	Vibration failure in stress relief pins between cover and locker body.	Hinge and pins redesigned to increase structural pins between cover strength. Item in fabrication and locker body for retest.

FAILURES RELATED TO MANUFACTURING PROBLEMS

	LINE ITEM	TITLE	PROBLEM	CORRECTION/STATUS
1.	HS-2	Waste Management Subsystem	Waste Processor chamber seal leakage failure. Manufacturing and Inspection problem with debris (metal clips) in seal grooves.	Seal groove cleaned properly and new seal installed. Unit retested satisfactorily.
2.	HS-19	Refrigeration Subsystem	Low temperature failure of temperature transducer (open circuit).	X-rays indicated a cold solder joint had been made. Also x-rays taken to verify production unit acceptability.
3.	HS-26	Vacuum Outlet System	Ball valve stem seal leakage due to improper installation.	Seals removed and correctly installed. Item retested satisfactorily. Line Item active in test.
4.	HS-55	Urine Centrifugal Separator Assembly	Vibration failure of pilot pickup tube due to improper installation	Another pilot pickup tube installed correctly and unit retested satisfactorily. Line Item active in test.

FAILURES RELATED TO PROCEDURAL PROBLEMS

	LINE ITEM	TITLE	PROBLEM	CORRECTION/STATUS
1.	ES-11	OWS Relay Modules	Modules cracked during shock test due to incorrect shock levels.	Revised specification and re-tested another module satisfactorily. Line Item closed.
2.	HS-8	Water Storage Assembly	Procedural problem resulted in dome collapse.	Procedure corrected and safety check valves added to test equipment. Unit given special test to verify acceptability. Unit accepted by engineering and presently in 8 month biocide test.

NASA

AEROSPACE SAFETY ADVISORY PANEL

SPECIAL OWS INTEREST ITEM NO. 6

The Panel showed particular interest in your management control identified as the Problem Control Center. We would appreciate a list of the problems currently identified and listed as active in this management control area and also a brief description of how the management system resolves these problems, using a single significant item as an example.

Problem Control Center (PCC)

The charter for the Problem Control Center as well as a functional flow chart are contained in enclosed Standard Practice 10.015-ACL. (Encl. 1)

List of Active Problems

The enclosed list of active problems is the same list as carried on the PCC board and presented to NASA and MDAC management on 4 November 1971 during the OWS Checkout Readiness Review. (Encl. 2)

The list contains 22 open nonconformances. Each was evaluated for impact on start of Phase I (Power Off) of checkout and was determined not to be a constraint. As may be noted in the "status" column, Interim Use Material (IUM) parts were employed as a work around in some cases. The majority (13 of 22) of the items have been resolved insofar as the installed hardware is concerned but remain open for management and/or recurrence control action. All items except one (Radiator Bypass Valve) are electrical and are targeted for resolution prior to Phase II (Power On) of Checkout which is scheduled to start 3 January 1972.

Sample Problem Handled by PCC

P/N 1B79441-1, Inductor
Supplier - Vanguard Electric Company
Failure Report - FARR 502 024 146 dated 30 April 1971 (Encl. 3)
Discrepancy - Loose leads found by Receiving Inspection on 85 of 85 incoming Inductors from supplier.
Problem Chronology:

- 4 May 1971 PCC became cognizant of problem and initiated preliminary investigation.

- 5-6 May 1971 PCC reviewed problem witn Receiving Inspection and Development Engineering personnel.

- 7 May 1971 PCC classified FARR as significant problem, notified management and posted problem on the PCC board.

Sample Problem Handled by PCC (Continued)

- 10 May 1971 PCC prepared initial Problem Report. (Encl. 4)
- 12 May 1971 convened and chaired a meeting of representations of all involved departments to brief the problem and to devise a recovery plan. (Encl. 5)
- 13 May 1971 Engineering issued Stop Orders on all next assemblies, established new drawing configuration and initiated necessary revision to applicable drawings. (Encl. 6)
- 20 May 1971 PCC issued "Recovery Plan" summary sheet to program management which statused progress to date. (Encl. 7)
- 24 May 1971 Problem held in PCC pending shipment of new parts.
- June 1971 Receiving Inspection performed at MDAC on new parts and verified acceptable.
- June 1971 Problem closed by PCC.

SAFETY PANEL QUESTIONS

1. Specific role MMC is playing in the contamination problem noted by Mathew's Team Review.

Answer - MMC has a variety of integration tasks concerning contamination. The objective of these tasks is to establish component/module contamination constraints and assure that these levels are reflected in appropriate design requirements specifications. They can basically be broken up into four major areas which are; 1) contamination control, ground operations; 2) on-orbit contamination assessment; 3) contamination modeling and analysis; and 4) ground tests.

Contamination control-ground operations establishes and assesses contamination levels, controls, and requirements applied to each module, experiment and GSE during periods of manufacturing, testing, handling, and transportation (including KSC operations).

On-orbit contamination assessment includes the determination of contamination sources, composition, and quantities of contamination to determine problem areas and recommend corrective action. This analysis is also used to determine the susceptibility of experiments and operational surfaces to contamination. Plans and procedures for real time mission evaluation of contamination for the Cluster is also established.

Analytical modeling and analysis covers developing analytical models that will predict the behavior of the contaminant cloud and surface desposition to establish the effects on operational conditions and materials. Baseline data for all models will be developed through reviews of industrial experimental test programs and ground tests programs which have been developed to provide specific data for these models.

The Skylab Contamination Ground test program is being run to obtain data on contaminate cloud behavior and surface deposition in a simulated space environment using the actual Skylab hardware where possible. Data generated by these tests will be used in the analysis effort previously described to check the validity of the math models in making pre-mission predictions of the extent and nature of contamination problems likely to be encountered.

2. Does MMC have as a SE&I task the assurance that cluster has across-the-board, consistent panel nomenclature, coordinate axes, etc?

Answer - There are no current SE&I tasks to assure that the cluster has across-the-board consistent panel nomenclature. Information on the status of the individual modules will be forthcoming since the module contractors are currently under contract to produce a document on panel nomenclature and MMC is planning to propose such a document for the experiments.

2. (Continued)

A level of commonality in this area has been accomplished through normal MMC participation in the various program reviews (PDR, CDR, C^2F^2, etc.). This type of activity will continue.

The Cluster Requirements Specification (CRS) requires that all modules eventually meet the requirements therein on the labeling of coordinate axes. There is no SE&I task to track compliance of this item.

The use of different types of switches, lighting, meters, etc. is another area of inconsistency for which no SE&I task exists. This situation has occurred by the levying of different constraints on the various contractors. For example, the ATM C&D console employs EL lighting and separate switches and circuit breakers whereas, the OWS employs overhead lighting and combination switches/circuit breakers.

The extent of inconsistency in the above areas as well as other areas will be determined during the planned Skylab Systems/Operations Compatibility Assessment Review (SOCAR). With this information, changes to the hardware will be recommended in order to accomplish cluster wide consistency, or ground rules and constraints will be changed where the Skylab schedule does not allow for hardware changes.

3. Rationale behind the extent of testing electronic boxes (Flight Units). Question arose on the "Using up of life" of boxes.

Answer - The design integrity of electronic Systems and Components is verified by development and qualification tests performed by the vendor during the development phase. Final confirmation of the flight article performance is accomplished by acceptance testing immediately prior to delivery by the vendor. The acceptance test provides the assurance that the flight hardware will perform in accordance with the technical criteria established in the end item specification. These components do not undergo any additional testing to verify their specific performance characteristics. They are, however, functionally operated after installation or incorporation into a higher assembly or system to verify performance on a total systems basis. In summary, the concept is one of taking proven components and electronic modules (Black Boxes) and incorporating them into vehicle systems, and then testing the complete vehicle system.

A final mission simulation test is then performed on the total integrated vehicle to insure mission compatibility of all systems and readiness for flight.

This concept results in a minimum testing of flight hardware prior to flight while achieving the required degree of assurance of hardware performance.

3. (Continued)

Components which have limited life in terms of operating time or number of cycles are identified and special controls have been established to limit and control the ground usage and test of these items.

4. CRT on ATM C&D Panel - how are these made "Safe"

Answer - Both types of Cathode Ray Tubes (CRTs) used in the ATM C&D Console include design features and qualification testing that demonstrates that they are safe under the conditions considered. These same conditions could cause hazardous ruptures when the glass faces of the CRTs are unprotected.

The design approach for one type of CRT, used for the two 6 1/2 inch monitors, was to apply an epoxy type coating over the glass face of the tubes. The design technique for the other CRT, the 1 1/2 inch X-Ray Scope, was to install the tube in a protective metal sleeve with a transparent end cap. This end cap has a Pyrex glass face and a Lexan plastic inner shield bonded to the metal sleeve. Specific design details are available upon request.

The two types of CRTs were subjected to the same standard impact test. This test consists of dropping a 50 gram steel ball from a height of eight (8) feet on the CRT faceplate. The results of the first drop on the TV Monitor CRT were satisfactory (no breakage) but impacted two (2) inches from the edge so the test was repeated. The second impact test resulted in a crack at the back of the TV tube. The test was considered satisfactory as the exposed surface, the faceplate of the CRT, did not break or fail.

The test results for the X-Ray Scope were satisfactory as there was no failure under these test conditions. Test results are available for conditions in excess of the requirements.

5. Question on "Closed loop" of changes at MSC that impact crew timelines and procedures.

Answer - During the recent Safety Panel review, it was pointed out that there was no closed loop configuration control system between the hardware change system and the procedures change system. This deficiency in the system has also been pointed out to CPD personnel. The Chief of the Crew Procedures Division has accepted an action item to investigate the control of all crew data. He in turn has assigned TRW to generate an initial "Crew Data Control Plan". A steering committee to input and critique this plan will be formed prior to February 24, 1972.

6. MMC-MDAC-E relationships on handling of MDA at MDAC-E. Include problems noted by MDAC-E's handling of MDA upon receipt at St. Louis.

Answer - MMC is experiencing the usual problems that could be expected of two large aerospace companies trying for the first time to work together. Generally MDAC-E has been cooperative, and does react to our needs. No major problems presently exist. There are several points of disagreement with respect to how to keep records, and general ways of doing business. However, these are being worked jointly, and satisfactory compromise solutions are expected.

7. Question on glass window re:

- Flight and Test articles from same batch?
- Design of installation. Hornbeck says it should be in compression only. MMC says no.

Answer - See attached letter to Dr. John A. Hornbeck.

8. Electrical wire in some cases not covered by metal or other cover to protect against inadvertant step on or other punishment.

Answer - Exposed cabling falls into three categories:

1. Cabling attached to items that involve in-flight maintenance and replacement. This is the category that most obviously falls into a class that might result in usage as a handhold, see the attached photograph. Every effort has been made to make the service loop as protected and as short as possible and still meet the requirements for easy astronaut service.

2. Cabling attached to components that are temporarily stowed for launch and then relocated. Obviously this is a temporary situation that is not an item of major concern.

3. Items not individually covered but are protected by surrounding structure or equipment. The basic approach to internal MDA wiring has been to minimize the possibility of wire damage by astronaut contact by either use of covered cable trays or placement of wiring in such a manner that there is little probability of accidental contact. All exposed wiring has been subject to detailed reviews by both MMC personnel and the astronauts based on this ground rule.

While we feel the present design has met our objectives it will be carefully monitored during training exercises and subsequent crew reviews such as participation in ground tests and C^2F^2 exercises. Any deficiencies noted will be corrected prior to flight.

9. More specifics on "open work" being shipped to KSC for MDA.

Answer - At the present time no modification kits for installation at KSC are programmed for any MMC built hardware. We are exercising top level management control of this situation and require the signature approval of the Vice President of Manned Space Systems before any such work will be authorized. There are several potential changes that will probably impact GFP installed in the MDA although the only fully defined item is a requirement to reinstall the Proton Spectrometer after rework and recalibration at MSFC.

10. Final results of analyses and closeout of Centaur examination.

Answer - The results of the Centaur report have been reviewed in depth by the Directors of Manufacturing and Test and of Quality. In addition Mr. Gerald Brewer of Langley who was a member of the investigating panel has been personally contacted at some length to get further insight to the problems uncovered. At this point in time we feel that wherever action was warranted we have initiated steps to achieve the necessary improvement. Closeout can only be achieved by monitoring the effectiveness of these actions.

11. Do you have a safety standard for operation of fork lifts and other materials handling equipment?

Answer - The Martin Marietta Corporation has a safety standard for the operation of company vehicles. This standard is V-4.0 dated 1-4-71 and is applicable to any company vehicle, including fork lifts.

The standard requires a periodic physical examination, requires a safety check list for the vehicle which must be completed prior to each operation of the vehicle and stipulates other requirements/safe practices while operating the vehicle.

12. When have the contents of this safety standard been reviewed with your materials handling equipment operators?

Answer - Safety Standards are periodically reviewed in the Industrial Safety "tool box" safety meetings.

13. Are your materials handling equipment operators regularly examined and certified?

Answer - Materials handling personnel receive regular physical examinations but are not certified for the job except in the case of crane operators/ riggers.

14. Do your industrial safety personnel review procedures for lifting and transporting high value hardware? Do they approve and sign?

Answer - MMC safety personnel review and approve all procedures involving movement of high value hardware.

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15. Are your industrial safety personnel involved in planning and advising on safe movements of high value hardware?

Answer - MMC safety personnel are involved in planning and actual move operations of all high value hardware.

16. Do your personnel involved in lifting and moving high value hardware have regular safety meetings? Do industrial safety personnel attend these meetings?

Answer - The movement team is always assembled for a pre-move meeting in which all pertinent details, including safety provisions, are discussed. Industrial safety and System Safety personnel attend these meetings.

MARTIN MARIETTA CORPORATION

DENVER DIVISION

POST OFFICE BOX 179 DENVER, COLORADO 80201 TELEPHONE (303) 794-5211

January 25, 1972

Dr. John A. Hornbeck
Sandia Laboratories
Albuquerque, New Mexico 87115

During your review of the Martin activity on Skylab on January 10th, you suggested a professional look at the MDA/EREP window installation. I would appreciate your identification of such a professional. We will proceed to contact that individual to arrange for his review of the design. Two consultants have previously been involved.

The first consultant that we engaged on the S190 Window was Mr. Joseph A. Kies who visited us on December 17, 1970. For many years Mr. Kies worked for the Naval Research Laboratory at White Oak, Maryland under the direction of Dr. G. R. Irwin who is a noted authority and has developed the technique of fracture mechanics on brittle materials.

Both Dr. Irwin and Joe Kies have retired from NRL after many years in the government service and Dr. Irwin is now a Professor in Mechanical Engineering at Lehigh University at Bethlehem, Pennsylvania. Mr. Kies is now a consulting engineer working for himself at the address 5407 Surrey Street, Chevy Chase, Maryland 20015. Mr. Kies is also consultant on a deep submergence vessel with glass windows for the Naval Research Laboratory and has also done consultant work for the Bureau of Standards in Washington. During his association with Dr. Irwin at NRL, Joseph Kies was in charge of all the experimental laboratory work associated with Dr. Irwin's fracture mechanics investigation.

The second consultant who helped us on the S190 Window was Mr. Leighton Orr who visited us on September 30, 1971 to discuss the results of our breaking strength tests on BK-7 glass.

Mr. Orr is Head of the Physical Testing Department, Glass Research Center, PPG Industries, Pittsburgh, Pennsylvania. He has been associated with Pittsburgh Plate Glass for over 20 years and it was here that he developed the concentric-ring method of testing glass specimens. Mr. Orr has been directly involved with the physically testing of literally thousands of pieces of glass, to determine the breaking strength of glass and, wherever possible, the cause of the failure by identifying the point at which the failure started whether it be surface scratch, surface crush, deep fissure, etc. Mr. Orr stated that we were conducting our tests properly and did not suggest any changes in our test procedure. He plans to retire in February, 1972.

A question with regard to whether the windows in the Program all came from the same glass melts was left unanswered during the meeting. Enclosure one supplies that information.

K. P. Timmons
Program Director
Skylab/MSFC

KPT:pn

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ENCLOSURE 1

BK-7 GLASS MELT DATA

OHARA GLASS COMPANY

	Usage	Melt No.	Structural Testing
1.	Experimental (Uncoated) Test Model - S190 Window (Full Size)	5210	18.6 PSI Press. (Window) Vibration, Shock, Impact
2.	Development Model S-190 Window (Full Size)	3948	18.6 PSI Press. (Window) Vibration, Shock
3.	Qualification Model S-190 Window (Full Size)	3948	30. PSI Pressure (Glass) 18.6 PSI Press. (Window) Vibration, Shock
4.	Flight Unit S-190 Window (Full Size)	5262	30 PSI Pressure (Glass) 12 PSI Press. (Window) Low Level Random Vibration
5.	Backup Unit S-190 Window (Full Size)	3705	Ditto
6.	Spare Glass No. 1 (Uncut)	5390	None
7.	Spare Glass No. 2 (Uncut)	5478	None
8.	Test Specimens (57) (6" Dia x 1/4)	5066	11 PSI Pressure Concentric Ring
9.	Test Specimens (63) (6" Dia x 1/4)	6010	11 PSI Pressure Concentric Ring
10.	Test Specimens (40) (6" Dia x 1/4)	5507	11 PSI Pressure Concentric Ring

John -
The working pressure during the manned mission is 5 PSID. Unmanned it is less.
Ken T

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

MAR 21 1972

REPLY TO ATTN OF: MM

TO: APA/Special Assistant, Aerospace Safety Panel

FROM: MM/NASA Director for Life Sciences

SUBJECT: Suggested Response to Action Item, December 1971, Aerospace Safety Advisory Panel Meeting - "ICONS"

Following the comments by Dr. Harold Agnew at the Aerospace Safety Advisory Panel meeting, the Office of Life Sciences undertook a review of the subject of ICONS (Stable isotopes of C, O, N and S). This examination looked at the subject of ICONS at two levels: (1) their use and application to Skylab (i.e., Skylab Medical Experiments Altitude Test /SMEAT/ and flight experiments); and (2) their subsequent applicability as a method for future measurements of biological factors.

The conclusions drawn from this review are as follows:

1. The availability of quantities of the various ICONS, up to now, has been quite limited. As a result, the experience with the use of these materials in ground-based laboratories is also quite limited at this time.

2. Until a sufficiently extensive data base is available upon which to reach a decision to substitute the use of an ICONS technique as a replacement for standardized and well established techniques, ICONS should not be recommended for use in flight programs such as Skylab (i.e. SMEAT and flight). It is concluded therefore that the substitution of ICONS techniques on Skylab is not advisable. As was presented at the Safety Advisory Panel meeting, the Skylab SMEAT is to be performed as near a ground-base dress rehearsal for the medical experiments to be done on the Skylab flights. The SMEAT therefore cannot be considered as a separate and discrete entity from the flight tests. Thus, the use of ICONS for the SMEAT is considered unacceptable as a substitute for a current onboard measurement or as a new ground technique to collect data for Skylab.

Attachment F

3. Extensive ground-based experience is also needed to establish the value of ICONS as a means for obtaining both new types of data and new measurements for the future. The use of ICONS do appear most promising and offers potential as a future research tool for biological measurements. To this end, NASA Life Sciences will continue to examine ICONS as a developing technology.

4. ICONS will be discussed at the next Life Sciences Committee (LSC) meeting (the scientific advisory group for NASA Life Sciences) in April. Dr. Wright Langham from Los Alamos is being asked by the LSC Chairman to present the AEC experience with these materials to the committee. Through this presentation and discussion, the LSC will have the opportunity to recommend what course NASA should take relative to the use of ICONS for the future.

The above review and the NASA conclusions, discussed above, were reached following Dr. Agnew's comments at the Aerospace Safety Advisory Panel meeting. We considered his comments about ICONS as being offered as a means for improving our data return from the Skylab ground testing program. We wish to thank Dr. Agnew for his comments because we feel that he has focused our attention to a very promising technique for the future.

Charles A. Berry M.D.

Charles A. Berry, M. D.